Master of its Domain

Integrated Energy System (IES) Powers Texas Multi-Use Complex

The U.S. Department of Energy (DOE), through Oak Ridge National Laboratory (ORNL), promotes advanced integrated energy systems (IES) which integrate power generation and thermal energy utilization technologies to meet electricity, heating and cooling requirements of nearby buildings.

ORNL subcontracted with Burns & McDonnell, the project developer, who teamed with Austin Energy, a municipal utility, to install and test an innovative IES. All of the exhaust heat from a gas turbine-generator is recycled to an absorption chiller. The system provides reliable power and chilled water cooling to The Domain in Austin, Texas.

Originally conceived of as a high-tech power park for data centers, The Domain's designers have responded to market demands by transforming it into a multi-use complex that includes business technology and high-end retail space.

Figure 1. *A 4.6 MW turbine supplies electricity and recoverable thermal energy to The Domain.*

System Technical Overview

The IES consists of a Solar Turbine gas turbine (see *Figure 1*) and a Broad USA chiller. The turbine exhaust drives the absorption chiller which is capable of displacing 2500 tons of electric centrifugal chilling at full base load. The IES is designed to run continually at full load, but with the latest control technology output can be reduced to the needed amount of chilled water. Additional electric energy can also be produced and used by Austin Energy.

Integrated Energy Systems (IES) are highly efficient onsite/near-site energy plants which combine distributed generation prime movers with thermally activated heat recovery equipment to simultaneously produce power, cooling and heating. These systems are pre-engineered optimizing use of the thermal energy output from the prime mover to provide space cooling and heating, process heat and dehumidification services to a building or campus improving fuel utilization and overall energy efficiency. Modular in design, these systems are replicable and scalable, giving them the flexibility to serve a wide variety of municipal, commercial and industrial applications.

Project Overview

LOCATION

The Domain Business Technology Park and High-End Retail Commercial Development | Austin, TX

DATE INSTALLED

2004

FACILITY

A multi-use complex that includes business technology and retail space

ELECTRIC & THERMAL

- 4.6 MW Centaur 50 Solar Turbine gas combustion turbine with 12.47 kV generator
- Broad Air Conditioning USA 2500-ton heat recovery double-effect absorption chiller

ENERGY SAVINGS POTENTIAL

- 18,000,000 kWh/Year *(avoided cooling electricity consumption)*

ENVIRONMENTAL BENEFITS

- Low output-based emissions of 0.24-lb NO_x/MW-h

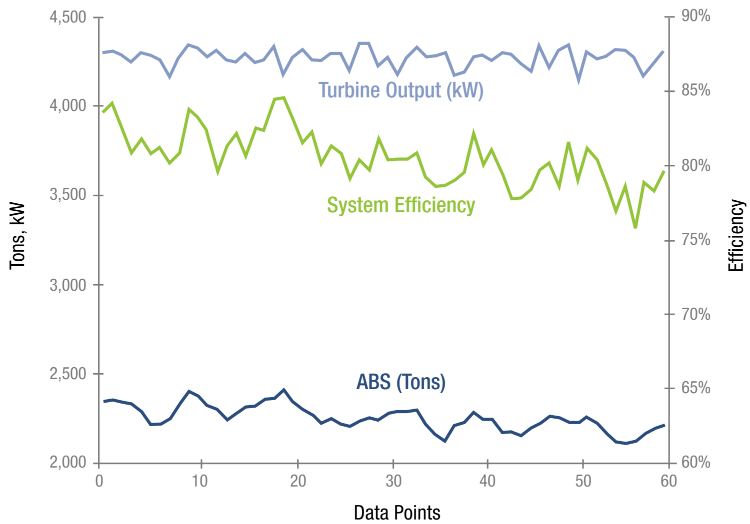
UNIQUE ASPECTS

- Fuel efficiency of 80%
- Absorption chiller runs solely on gas turbine exhaust heat
- Modular system makes installation possible at almost any location at reduced cost

The system's net output of 4.3 MW is produced with less than 15 ppm NO_x emissions for the gas turbine. The Texas Commission on Environmental Quality established an "output based" emissions standard of 0.47-lb NO_x/MW-h that credits use of thermal energy. At 0.24-lb/MW-h, the system output falls below this limit without using additional selective catalytic reduction equipment.

IES can be very efficient, as well as clean. In the fall of 2004, testing verified The Domain IES fuel efficiency of 80% (see *Figure 2*). When compared to the national central generation average efficiency of 32%, it's not surprising that the IES plant in Austin generated excitement.

Figure 2. Absorption Chiller Tons, Turbine kW, and System Efficiency



System Design

Burns & McDonnell developed, installed, and tested this "packaged IES," with support from the Department of Energy. The IES is the largest system in the nation to use the approach of recycling waste heat to drive an absorption chiller. The design team developed it to run solely on gas turbine exhaust. The system doesn't need steam, natural gas, or hot water to drive the absorption chiller. It combines a natural gas fired 4.6 MW combustion turbine generator to produce power with an advanced exhaust fired 2,500 ton double-effect absorption chiller to produce cooling. The electricity can be used on-site and/or be exported and used by the project partner, Austin Energy.

The team designed a modular system made up of seven components for ease of installation. Engineers considered varying equipment, electrical and piping layouts and various capacity, space and grid interconnection requirements. The Burns & McDonnell design team received an Engineering Excellence Award from the Texas Council of Engineering Companies because of the advancements made during the development and implementation of the project.

System Performance

The Austin IES plant is one of the first successful installations of this type of IES to be completed on such a large scale. The gas turbine's exhaust heat evaporates water from lithium bromide (a natural absorbent). The resulting vapor condenses to produce more than 2,500 tons of chilled water at full capacity. A diverter valve and a stack are mounted between the turbine and the chiller to modulate the flow of exhaust through the chiller. This controls the amount of chilled water produced by the system. The combustion inlet cooling module uses a portion of the chilled water (200-300 tons) to cool the combustion turbine inlet air, improving electric generator output on hot days and system efficiency (see *Figure 3*). The remaining chilled water output serves the site's cooling load by supplying a district chilled-water system.

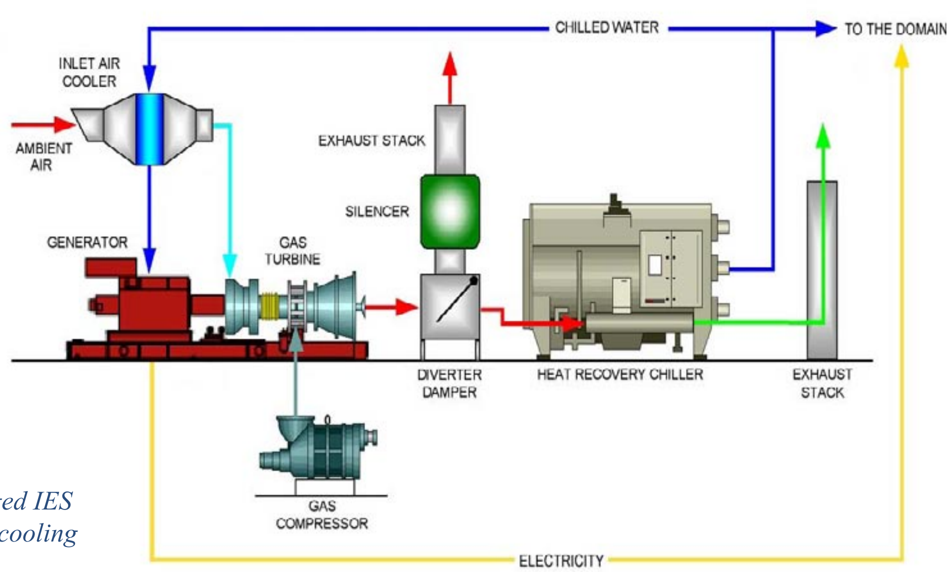


***Figure 3**. The Domain packaged IES produces electricity and cooling*

Financing

The development and implementation of the IES plant was made possible under a government development contract. DOE and Oak Ridge National Laboratory awarded it to Burns & McDonnell, who teamed up with Austin Energy —a municipal energy company. DOE contributed $3 million to the project for research and development work including development of modular components. Tests were conducted and performance was reported at the system and component level. Austin Energy contributed $5.3 million for the plant equipment, modular installation, and start-up and interconnection to the power grid.

Economic Analysis

In order to predict the IES's economic performance, a modeling tool was developed. The tool accounted for technical and economic factors including:

- Full use of the thermal output
- The configuration and components of the heat recovery system
- Payback of capital costs through long-term operating cost savings
- Economic sensitivity to natural gas and electricity prices
- Economic sensitivity to the revenue rate for chilled water and electricity produced by the system
- Annual operating hours of the system
- Number of hours during which the system is thermally base-loaded

Comparisons were made between various equipment configurations. The elimination of the requirement to produce steam, for example, cut capital costs by 10-15% in comparison to steam-driven absorption chillers.

The IES plant does have higher initial costs than an electric system, but thermal products provide more economic value than electricity. Its capital cost is $8 million, while an electric system would be only $3 million. The parasitic load for the IES is 0.4 kW/ton (including gas compressor) while the electric centrifugal chiller uses 0.9kW/ton (see *Figure 4*).

Under base load operating conditions (8000 hours annually), the IES has a net present value of $16M with a 19% internal rate of return. If the system is operated fewer than 4500 hours, the model predicts that the running the electric chillers would be more economic (see *Figure 5*). Simple payback on the $8.3M capital investment is seven years.

End-User Perspective

Packaged IES's, made possible by public/private partnerships, have been designed to cut installation costs and time. The success of packaged IES plants such as that found at The Domain is a strong indicator that with lower initial costs and much higher efficiencies, a gas powered generation system can still be competitive even when using more expensive fuel.

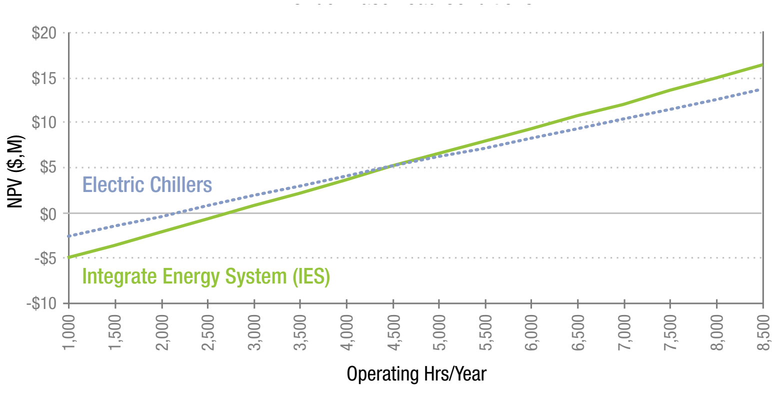
Austin Energy's Director of Business Development, Cliff Braddock, indicates that this new approach to on-site generation may be competitive even when compared to conventional power plant technology.

"If you compare the energy content of fuel inputs for an IES system to the best combined cycle power plants, the IES system is capable of providing more useful work using less fuel input. Less fuel input can result in lower emissions also. Since the IES system recycles waste exhaust heat, it becomes a more efficient means to produce cooling, heating and electricity when compared to the traditional central station power plant and customer sited electric chillers and boilers. And when you look at the financial analyses, you will find that thermal products provide more economic value than the electricity," according to Braddock.

***Figure 4.** Summary of Projected Annual Energy Savings Under Base Load Operating Conditions*

Cooling Produced *(Assuming 8,000 hours/year of base-load operation)*	20,000,000 Ton-Hours/Year
Avoided Cooling Electricity Consumption *(Assuming electric centrifugal chiller load of 0.9 kW/Ton)*	18,000,000 kWh/Year
Total kWh Savings *(Assuming IES parasitic load of 0.4 kW/Ton and $0.05/kWh electricity cost)*	$500,000/Year

***Figure 5.** IES Net Present Value increases with Annual Operating Hours*



Replicability

DOE's Distributed Energy (DE) Program selects projects that are highly replicable, or that can be duplicated in applications with characteristics similar to DE Program-supported projects.

The Burns & McDonnell IES was designed with replicability in mind. It stresses both flexibility and modularity. In its project design, engineers separated the equipment into seven components or modules:

- Inlet air filter and cooling module
- Gas compressor module
- Gas turbine module
- Absorption chiller module (see *Figure 6*)
- Chiller exhaust stack module
- Chilled water pump and control module
- Bypass damper stack module

Figure 6. *2,500-ton absorption chiller is one part of modular approach to replicability*

Such a design allows the system the flexibility to be used in various capacity and space limitations, as well as meet existing grid interconnection requirements. The modules come almost completely assembled by the manufacturers, making it easier to replicate and construct than similar IES's. They can be disconnected, mounted on trucks, and moved to new locations. This integrated IES design can be built at a customer's facility almost anywhere in the world.

In addition, the standardized packaged design should cut capital costs by 15-30%. Lowering the initial costs of the IES shortens the payback period and allows on-site energy systems to be more competitive.

Multi-use complexes such as The Domain have the advantage of diverse thermal loads. For example, a hospital requires continuous energy (24/7/365) while commercial buildings need energy during the day (peak periods of energy use), and residences need energy during the evening. By combining these building energy use patterns, developers of mixed-use sites achieve more diverse thermal and electric load profiles that can be managed more efficiently—especially when an advanced IES is operated on-site. Because of these advantages, The Domain IES is being replicated at Dell Children's Medical Center, the anchor tenant of an Austin, Texas, mixed-use site.

Helpful Web Sites

- **Distributed Energy Program**
  www.eere.energy.gov/de/
- **Oak Ridge National Laboratory**
  www.ornl.gov/sci/engineering_science_technology/cooling_heating_power/
- **Gulf Coast Regional CHP Application Center**
  www.gulfcoastchp.org
- **Austin Energy**
  www.austinenergy.com
- **Burns & McDonnell**
  www.chpbmcd.com

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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